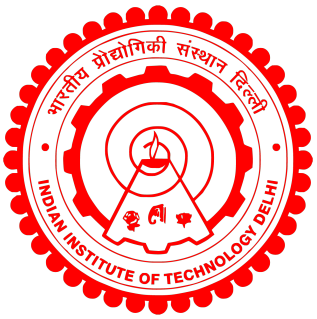

ELP305: Wet Cleaning Machine Requirements

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Contents

1 List of Tables used

1. Glossary
2. Input Requirements - Summary

2 List of Figures used

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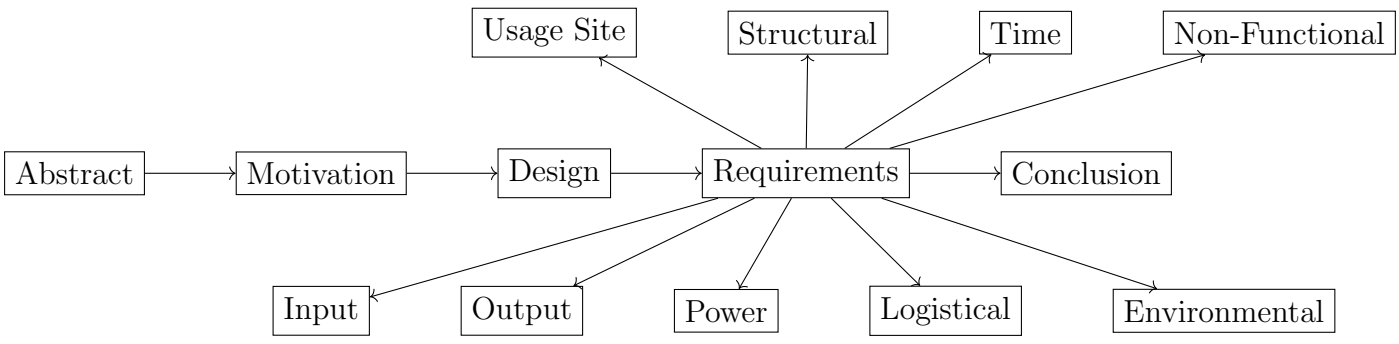
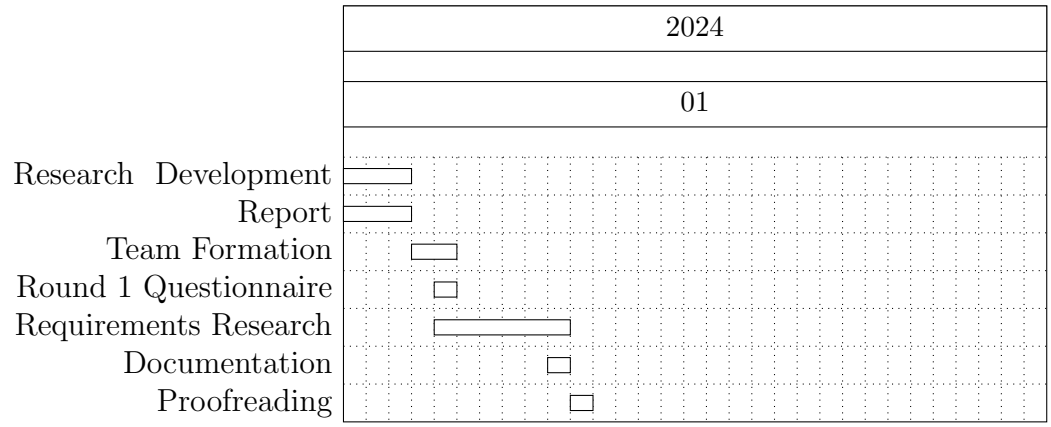
2. Chemical Cleaning Methods Mindmap

3 Glossary

Term	**Definition**
Abrasion Resistance	Abrasion Resistance refers to the ability of a material to withstand wear, rubbing, or friction, maintaining its surface integrity and resisting damage caused by repeated contact with abrasive forces or surfaces.
Tear Strength	Tear strength is a measure of a material's resistance to tearing or the force required to propagate a tear, indicating its durability against the initiation and growth of a tear or cut.
Seam Slippage	Seam spillage is the undesired leakage of contents through container seams due to inadequate sealing, posing a risk of material loss.
Denier	Denier is a unit of measurement for the linear mass density of fibers, indicating the weight in grams of a 9,000-meter length, commonly used to express the thickness or fineness of yarn in the textile industry.



4 Project Management Details



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Finish: 5/1/24

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Abstract

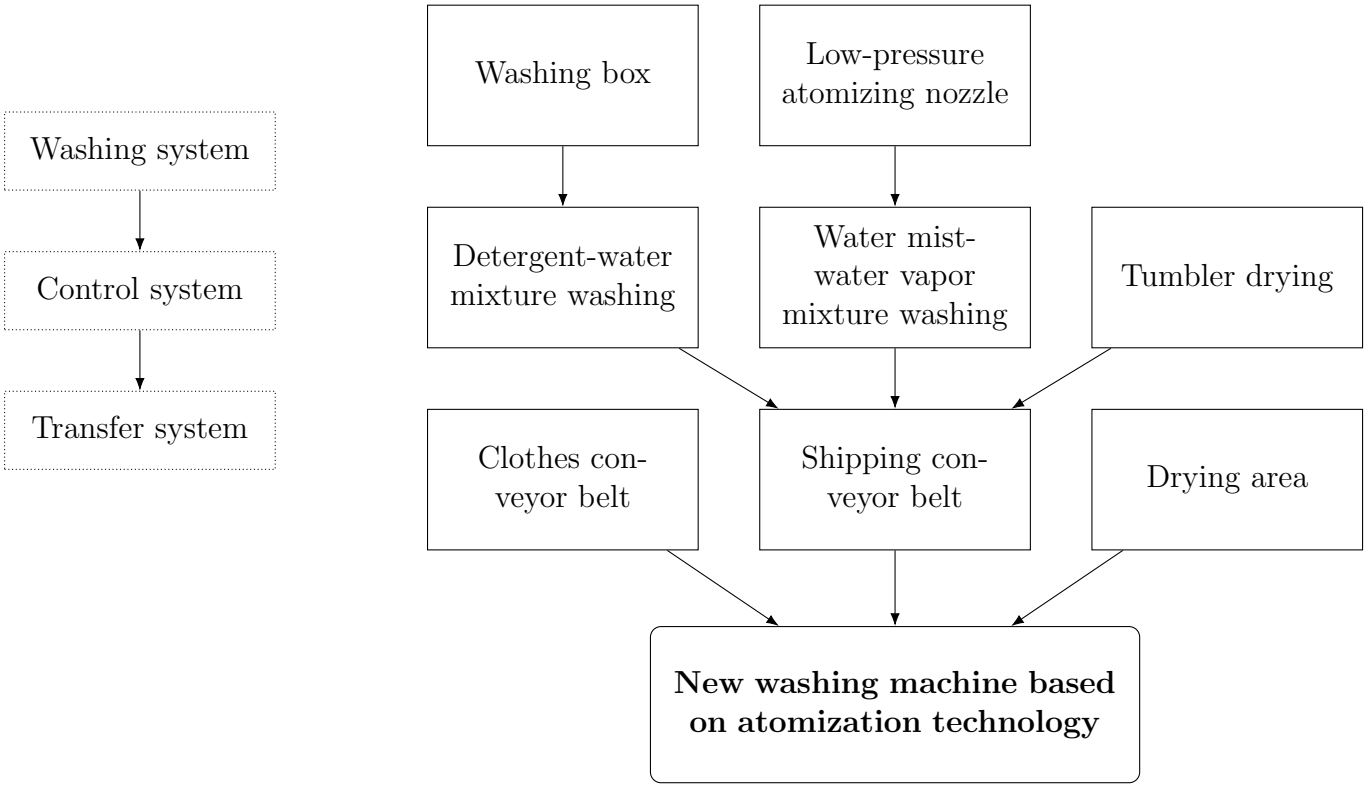
The design document outlines a comprehensive approach to creating a cleaning machine tailored for white unbleached cotton fabric. The fabric specifications include a new, 400-thread count, 60-denier cotton fabric with a dry weight of 11 kgs to be washed in a 45-minute single cleaning cycle. The machine is designed to accommodate a maximum fabric width of 2 meters, ensuring efficiency and practicality. Environmental considerations are integrated into the design, utilizing non-toxic, biodegradable detergents for wet cleaning, aligning with sustainability standards. The machine's structural components, such as the rotating drum and water mist-steam cleaning module, are strategically designed to optimize the cleaning efficacy while preserving fabric integrity. The machine's operational features include an integrated system for introducing wet cleaning chemicals at specific stages, ensuring precise timing to maximize effectiveness while minimizing adverse effects on fabric quality. The use of a Programmable Logic Controller (PLC) and a Human-Machine Interface (HMI) enhances operational control and user interaction. In terms of efficiency, the tumble drying process[1] is highlighted, utilizing a rotating drum [2] with hot air circulation. The machine structure is outlined, encompassing inner and outer components, sensors, pumps, valves, and safety features. Regular cleaning and maintenance considerations are incorporated to manage lint buildup and ensure long-term reliability. The fabric and machine specifications are meticulously addressed, considering factors such as tear strength, temperature range, flammability, power load preferences, and batch size. The design emphasizes adaptability to different cleaning methods (water, dry, air) and remains cost-effective while adhering to a maximum power load of 1-phase 220V 15A or 3-phase 440V 8A.

6 Motivated Design: Synergizing Wet Cleaning with Spray Washing

Our inspiration for the Cotton Fabric Cleaning Machine stemmed from the client's specific need to clean new white unbleached cotton fabric, emphasizing a pre-packaging cleaning solution for fabric manufacturers. To meet these demands effectively, our design strategically integrates the proven benefits of Wet Cleaning with the advanced features of Spray Washing [3]. Motivated by the desire to optimize stain removal, fabric preservation, and overall cleaning efficacy, we seamlessly blended Wet Cleaning's non-toxic, biodegradable detergents with the precision of a Spray Washing Machine. This innovative approach not only addresses manufacturing impurities but also enhances the machine's capabilities for odor removal and environmental friendliness. Understanding the importance of versatility, the design accommodates various cleaning methods, including water, dry, and air, ensuring adaptability to different fabric handling needs. The motivation to adhere to power load preferences further ensures cost-effectiveness and safety in operation. The user-centric design principles are rooted in the desire for efficiency and ease of operation. The 45-minute single cleaning cycle and a balanced machine size cater to the client's need for practicality and user-friendly experience. Economically driven, the design is cost-effective, aligning with budgetary constraints while adhering to environmental standards, as mandated by CPCB rules. In essence, our motivation behind this integrated design is to provide a holistic fabric care

solution that not only meets but exceeds client expectations through the seamless synergy of Wet Cleaning and Spray Washing technologies.

6.1 Machine Design Mindmap



7 Requirements

7.1 Input Requirements

Q. *Are there any particular types of stains or fabrics the machine should be optimized for?*

A. White unbleached Cotton fabric which has been just manufactured.

Q. *Who is the intended user of the cleaning machine?*

A. The entity who made the unbleached cotton fabric.

Q. *What would be the desired fiber content for the fabrics?*

A. Single ply, thread count 400 and denier 60.

Q. *What types of yarn are commonly used in the fabrics you intend to clean?*

A. Cotton yarn

Q. *What is the maximum dimensions of the fabrics that the cleaning machine should accommodate?*

A. Dimension is 10 meter length (max) x 2 meters width (max)

Q. *What is colorfastness to laundering i.e fabric colour's resistance to fading/running to laundering (Grade 1-5)?*

A. Colours are fast, they do not run. Primarily the input is NOT coloured - white unbleached cotton cloth.

Q. *Are there specific requirements for abrasion resistance, especially for fabrics that may undergo frequent cleaning cycles?*

A. Each fabric undergoes one cleaning and is then packed.

Q. *What are the minimum tear strength specifications?*

A. 125 kg (tensile method test)

Q. *Is seam slippage a critical factor, and if so, what levels are acceptable for the fabrics?*

A. No, the edges of the fabric are back-folded seams.

Q. *What are the flammability characteristics of the fabric?*

A. Flammable if exposed to naked flame for more than 6 seconds.

Q. *Are there some stains/impurity industry specifically added during the manufacturing process and needs to be cleaned before packing?*

A. No, stains are not deliberately added. Only impurities are the materials used to manufactures the cloth.

7.1.1 Input Requirements - Summary

Key Consideration	Requirement
Types of stains or fabrics the machine should be optimized for	White unbleached Cotton fabric which has been just manufactured
The intended user of the cleaning machine	The entity who made the unbleached cotton fabric
Desired fiber content of the fabrics	Single ply, thread count 400 and denier 60
Types of yarn commonly used in the fabrics to be cleaned	Cotton yarn
Maximum dimensions of the fabrics that the cleaning machine should accommodate	10 meter length x 2 meters width
Fabric's colorfastness to laundering	Colours are fast, they do not run. Primarily the input is NOT coloured - white unbleached cotton cloth
Specific requirements for abrasion resistance, especially for fabrics that may undergo frequent cleaning cycles	None. Each fabric undergoes one cleaning and is then packed
Minimum tear strength specifications	125 kg (tensile method test)
Is seam slippage a critical factor, and if so, the acceptable levels for the fabrics	No, the edges of the fabric are back-folded seams
Flammability characteristics of the fabric	Flammable if exposed to naked flame for more than 6 seconds
Stains/impurity industry specifically added during the manufacturing process that need to be cleaned	No, stains are not deliberately added. Only impurities are the materials used to manufactures the cloth

Table 5: Input Requirements

7.2 Output Requirements

Q. *What would be the Weight of the cloth being fed into the machine?*

A. 11 kg dry weight

Q. *Do the clothes require water cleaning, dry cleaning or air cleaning?*

A. They are raw unbleached cloths which have just been manufactured / made - you decide which cleaning they need.

Q. *Are there any size constraints for the cleaning machine?*

A. No. A bigger machine will probably be more difficult to make and will make your product costlier than your competition. You decide how small you can get away with.

Q. *How frequently should the machine be cleaned?*

A. That is as per your design.

Q. *How Frequently is the machine used (is it continuous-running or used sparingly)?*

A. Continuously.

7.3 Power Requirements

Q. *What is the Maximum Power Load allowed for the machine?*

A. 1-phase 220V 15A ; 3-phase 440V 8A, power consumption must be minimum as possible

7.4 Logistical Requirements

Q. *Should the machine be portable or designed for fixed installation?*

A. If you are costlier than your competitor, I will buy from them not from you.

7.5 Environmental Requirements

Q. *Any particular environmental constraints to be taken of?*

A. Environment: must comply with CPCB rules.

7.6 Site (Usage Site) Requirements

Q. *Could you tell us about the water availability and quality at the site?*

A. Water (hardness 60 mg CaCO3/l) is available at ambient temperature in a overhead (35 m height) tank of 50000 litre capacity which can be refilled.

7.7 Time Requirements

7.7.1 Design Time Requirement

Q. *How long must it take to wash the fabric?*

A. 11 kgs of dry weight cloths to be washed in 45 minutes

7.8 Other Non-Functional Requirements

Q. *Is the machine being used continuously?*

A. yes

8 Machine Requirements

8.1 Inputs Requirement

- **Water:** Essential for the washing process, water acts as a medium for the wet cleaning agents, facilitating effective stain removal and cleaning. The rationale is based on the principle that water is a universal solvent, enhancing the breakdown of dirt, oils, and stains on unbleached white cotton fabric.

- **Non-toxic, biodegradable detergents:** The integration of these detergents aligns with the environmentally friendly approach of wet cleaning. Detergents like EcoClean™ and PureCottonCare™ are specifically formulated to optimize cleaning while minimizing color changes and shrinkage, preserving fabric integrity.
- **Pre-spotting agents, Fabric softeners, FeCl3/PTES solution, Finishing chemicals, Sizing agents:** These integrated chemicals provide a comprehensive approach to fabric care. Pre-spotting agents target specific stains, fabric softeners restore texture, FeCl3/PTES solution treats fabric, finishing chemicals enhance appearance, and sizing agents add body to the fabric. Sequential introduction ensures optimized effectiveness during the cleaning cycle.
- **Wet fabric for tumble drying:** The wet fabric from the cleaning process serves as the input for tumble drying. The rationale is to transition from the wet cleaning stage to the drying process seamlessly, maintaining efficiency in the overall fabric cleaning and care.
- **Power source for electric motor and heating elements:** Electricity powers the motors driving the washing and drying processes, as well as the heating elements essential for effective cleaning and drying. The rationale is based on the need for controlled and precise mechanical movements and the application of heat during these processes.

8.2 Outputs Requirement

- **Clean and fresh-smelling unbleached white cotton fabric:** The ultimate goal of the integrated cleaning system is to deliver unbleached white cotton fabric that is free of stains and dirt.
- **Dry fabric:** Tumble drying ensures the efficient removal of moisture from the fabric, providing a quick and convenient way to transition from wet to dry fabric. The rationale is to complete the fabric care cycle, delivering a fully cleaned and dry end product to the user.
- **Lint and waste generated during the drying process:** Byproducts like lint and waste are generated during the drying process, emphasizing the need for regular cleaning and maintenance. The rationale is to manage the accumulation of these byproducts, ensuring continued efficiency and preventing potential hazards.

8.3 Power Requirements

- **Electricity for the spray washing machine, tumble drying machine, and associated systems:** The integrated cleaning system relies on electricity to power the motors of the spray washing machine, the tumble drying machine, and other associated systems. The electricity requirements will be well under the available maximum limit of 1-phase 220V 15A and 3-phase 440V 8A.
- **Heating elements for the washing and drying processes:** Heat is applied during both the washing and drying processes to optimize cleaning efficacy and facilitate moisture removal. The rationale is to enhance the breakdown of stains during wet cleaning and ensure thorough drying in the tumble drying stage.

8.4 Logistical Requirements

- **Adequate space for the spray washing machine, tumble drying machine, and associated systems:** The machines need sufficient space for installation and proper functioning. The rationale is to provide the necessary physical infrastructure for the cleaning and drying processes.
- **Water supply connection:** An essential logistical requirement for the washing process, the water supply ensures the availability of the medium for wet cleaning agents. The rationale is grounded in the necessity of water as a key component for effective wet cleaning.
- **Ventilation for efficient drying:** Proper ventilation is crucial during the tumble drying process to facilitate the efficient removal of moisture from the fabric. The rationale is to create an environment that supports optimal drying conditions, ensuring the effectiveness of the drying process.

8.5 Environmental Requirements

- **Use of biodegradable detergents:** The integration of biodegradable detergents aligns with modern sustainability standards, reducing the environmental impact of the cleaning process. The rationale is to contribute to eco-friendly practices in fabric care.
- **Effluent treatment system for environmental compliance:** The system includes an effluent treatment component to responsibly manage wastewater and adhere to environmental regulations. The rationale is to mitigate the environmental impact of the cleaning process by treating and controlling the disposal of wastewater.
- **Good ventilation for efficient drying:** Beyond its role in efficient drying, good ventilation also contributes to environmental considerations by optimizing energy efficiency during the tumble drying process.

8.6 Site (Usage Site) Requirements

- **Well-ventilated space for drying:** The drying process requires a well-ventilated space to ensure optimal conditions for moisture removal. The rationale is to create an environment that supports efficient drying and prevents issues like excessive humidity.
- **Access to water supply:** A necessary site requirement for the washing process, ensuring a constant supply of water for the wet cleaning agents. The rationale is grounded in the need for a consistent and accessible water source for effective cleaning.
- **Proper installation of inner components in machine structures:** Ensuring proper installation of inner components is vital for the overall functionality of the machines. The rationale is to guarantee that all components work in harmony to achieve the desired cleaning and drying outcomes.

8.7 Structural Requirements

- **Sturdy housing for the spray washing machine and tumble drying machine:** Sturdy housing is crucial to provide stability and durability for both machines. The rationale is to ensure the machines can withstand the mechanical movements and operational demands without compromising performance.
- **Rotating drum, material introduction system, heat source, exhaust system, and other components for efficient drying:** Each component has a specific role in optimizing the tumble drying process. The rationale is to integrate these components cohesively, allowing for efficient and effective fabric drying.
- **Adequate support for inner components in machine structures:** Proper support for inner components is necessary to prevent malfunctions and maintain the overall integrity of the machines. The rationale is to ensure that all components are well-supported and can perform their functions optimally.

8.8 Time Requirements

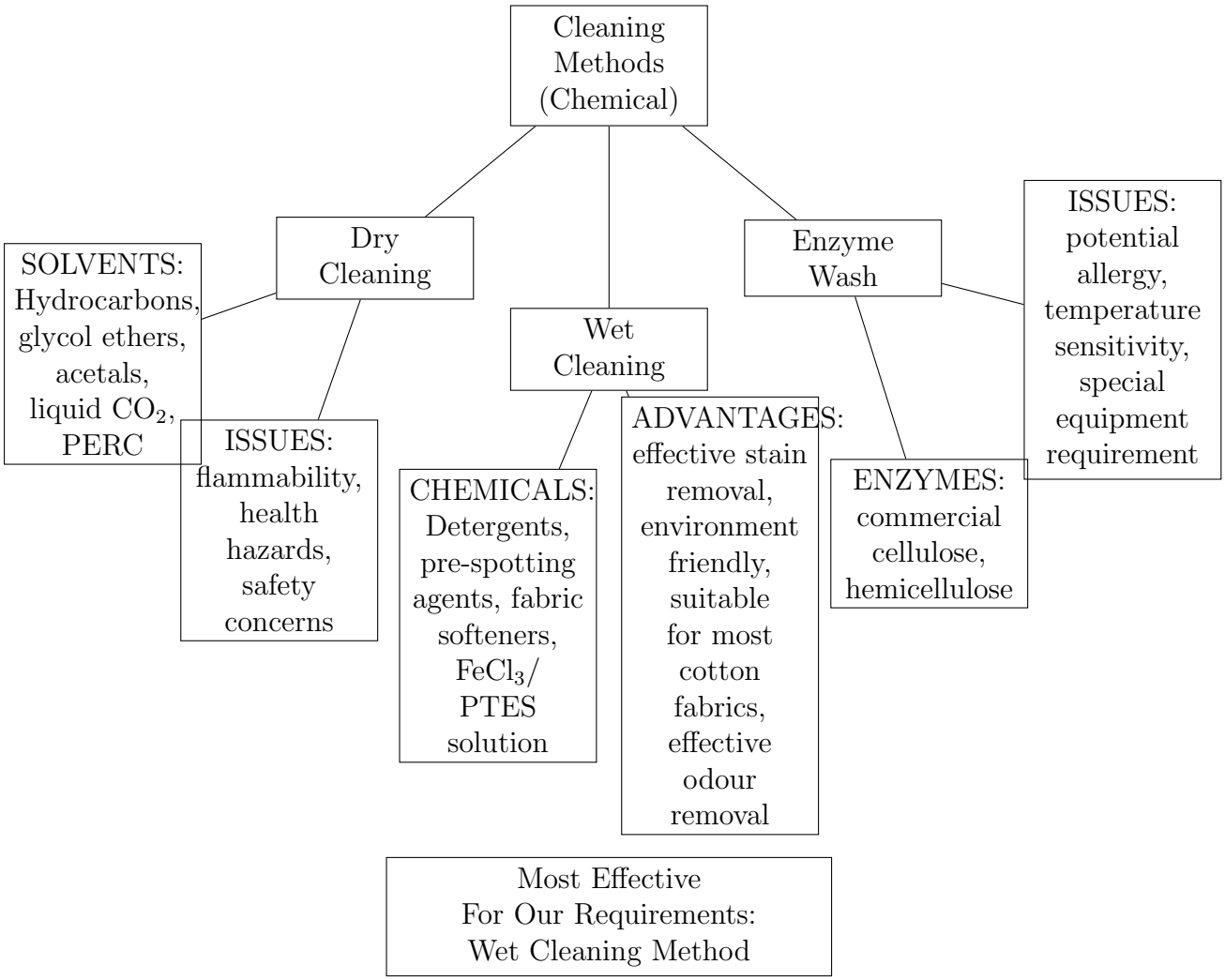
- **Design Time Requirement:** Drawing insights from prevalent industry benchmarks in designing cleaning machines for unbleached cotton fabric, our objective is to streamline the design process within a timeframe of around 4 weeks. This aims not just to meet but to surpass contemporary design efficiency, employing innovative methodologies for optimal system performance.
- **Time to Market Requirement:** Comparative analysis of industry timelines underscores the variability in design-to-market durations for cleaning machines. Our commitment is to adhere to or potentially outstrip these norms, ensuring our systems reach the market promptly to address evolving demands through precision and efficient collaboration.
- **Life Time Requirements:** Acknowledging the diverse operational lifespans of machines in the industry, our focal point is to gain a competitive advantage by delivering robust systems with prolonged operational life. Through meticulous design and stringent quality assurance, our aim is to set new industry benchmarks in system longevity.
- **End of Life Requirements:** In navigating the stages of disposal, recycling, and maintenance, industry practices exhibit variability. In our commitment to environmental responsibility, we envision surpassing standard guidelines. As the project progresses, our goal is to introduce procedures that not only meet but exceed existing industry standards, elevating the sustainability and lifecycle management of our systems.

8.9 Other Non-functional Requirements

- **Safety:** Implementation of safety features such as emergency stop buttons and safety sensors. The rationale is to prioritize user safety during the operation of the machines, minimizing the risk of accidents or malfunctions.

- **Serviceability:** Access panels provided for maintenance ease. The rationale is to facilitate easy maintenance and servicing, allowing technicians or users to access internal components for repairs or cleaning without significant disruption.
- **Reliability:** Consistent and reliable performance is essential for effective cleaning and drying. The rationale is to build machines that users can trust to deliver consistent results, meeting their fabric care needs reliably.
- **Efficient Water Flow Regulation:** Control of water inflow and outflow for optimal usage. The rationale is to ensure that water is utilized efficiently during the washing process, contributing to resource conservation and cost-effectiveness.
- **Turbidity Control:** Monitoring and control of water turbidity for effective cleaning. The rationale is to maintain the clarity of water during the washing process, enhancing the performance of wet cleaning agents and improving overall cleaning efficacy.
- **Inlet and Outlet Timing:** Optimal timings for water inlet and outlet during different phases of the cleaning process. The rationale is to synchronize water flow with specific stages of the cleaning cycle, optimizing the effectiveness of detergents and rinsing.
- **PLC for Operation Control:** Use of a Programmable Logic Controller for efficient operation control. The rationale is to implement advanced control systems that enhance the precision and automation of the cleaning and drying processes, ensuring consistent and controlled performance.
- **HMI for User Interface and Monitoring:** Incorporation of a Human-Machine Interface for user-friendly interaction and monitoring. The rationale is to provide users with an intuitive interface to control and monitor the cleaning and drying processes, enhancing the overall user experience.
- **Environmental Considerations:** The overall system design takes into account environmental impact and sustainability, incorporating elements such as biodegradable detergents, effluent treatment, and energy-efficient processes. The rationale is to align the system with modern environmental standards and practices.
- **Effluent Treatment System:** Ensures responsible management of wastewater, minimizing environmental impact. The rationale is to address environmental concerns related to wastewater disposal and contribute to sustainable and responsible fabric care practices.
- **Regular Cleaning and Maintenance Time:** Design includes provisions for regular cleaning and maintenance to prevent issues such as lint buildup and ensure long-term functionality. The rationale is to promote proactive maintenance, extending the operational life of the machines and preventing potential breakdowns.

8.10 Chemical Cleaning Methods Mindmap



References

[1] J. Deans. The modelling of a domestic tumbler dryer. *Applied Thermal Engineering*, 21(9):977–990, June 2001.

[2] Hee-Tae Lim, Weui-Bong Jeong, and Keun-Joo Kim. Dynamic modeling and analysis of drum-type washing machine. *International Journal of Precision Engineering and Manufacturing*, 11(3):407–417, June 1 2010.

[3] Dun Liu, Ruoyu Hu, and Weigang Zheng. Research and design of a new type of spray washing machine. *IOP Conference Series: Materials Science and Engineering*, 688(3):033070, November 1 2019.

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